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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

FRANK D. GARDNER, Special Agent in Charge,

Mayaguez, September, 1902.

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Bulletin No. 2.

THE CHANGA, OR MOLE CRICKET

(*Scapteriscus didactylus* Latr.)

IN

PORTO RICO.

BY

O. W. BARRETT,

Entomologist and Botanist, Porto Rico Agricultural Experiment Station.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:

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[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

STATION STAFF.

FRANK D. GARDNER, *Special Agent in Charge.*
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Withdrawn
8/12/48

LETTER OF TRANSMITTAL.

MAYAGUEZ, PORTO RICO, *September 13, 1902.*

DEAR SIR: I have the honor to transmit herewith a manuscript, entitled "The Changa, or Mole Cricket, in Porto Rico," prepared by Mr. O. W. Barrett, entomologist and botanist of the Porto Rico station. The attacks of this insect extend to nearly all classes of crops and the loss from its ravages amounts to many thousands of dollars annually. In economic importance to the planters here it far exceeds that of any other insect, and the question most frequently asked by visitors to the experiment station has been, "How can we get rid of the changa?" Since beginning experimental work last October, sufficient time has not yet elapsed to have completed the study of its life history, neither have the remedial measures thus far tried been so satisfactory as to justify discontinuing further investigations with reference to the extermination of this most important insect. Much valuable economic material, however, has been acquired, and in view of the pressing demand for this kind of information by the Porto Rican planters I respectfully recommend the publication of the article, in both English and Spanish, as Bulletin No. 2 of the Porto Rico Agricultural Experiment Station. The manuscript has been submitted to and approved by Dr. L. O. Howard, Entomologist of the U. S. Department of Agriculture. Under his direction it was read by one of his assistants, Mr. F. H. Chittenden, to whom acknowledgment is made for a number of corrections and suggestions and for the supervision of the drawings of the insect used in preparing the illustration.

Very respectfully,

FRANK D. GARDNER,
Special Agent in Charge of Porto Rico Experiment Station.

Dr. A. C. TRUE,
Director, Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Description	5
Life history	7
General habits	8
Food habits	9
Introduction into Porto Rico	10
Influence of soil conditions	10
Remedies	11
Natural enemies	17
Summary	19

ILLUSTRATION.

	Page.
FIG. 1. Changa (*Scapteriscus didactylus* Latr.): Adult from above at left, from side at right	5

THE CHANGA, OR MOLE CRICKET (*Scapteriscus didactylus* Latr.) IN PORTO RICO.

Since the hurricane of 1876 the mole cricket (*Scapteriscus didactylus*), or "changa," as it is popularly called, has continued to be by far the most serious insect pest that the Porto Rican agriculturist has had to deal with. Its damages to tobacco, cane, and small crops in the island amount to probably more than one hundred thousand dollars annually. Its habits are well understood by the planters, but there seems as yet to be no definite method of combating it successfully, and an authority states that "nothing appears to be known of its economic status."

Though the species of mole cricket common in Porto Rico has been known for many years, it seems that Brunner and Redtenbacher were the first to report it [1892] as inhabiting this island; and although it is known to occur from Uruguay to Florida on the continent, and also in Cuba, Jamaica, Haiti, and St. Vincent in the West Indies, it appears to be more injurious to agriculture in Porto Rico than elsewhere.

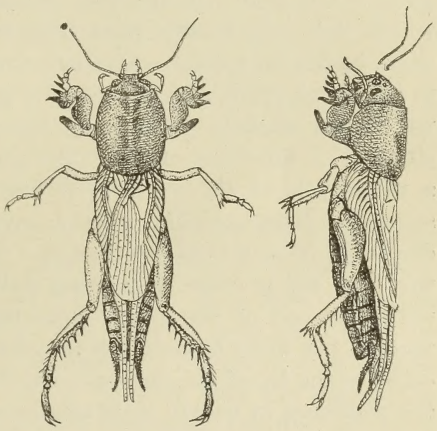

FIG. 1.—Changa (*Scapteriscus didactylus* Latr.): Adult from above at left, from side at right (from drawing made in the Division of Entomology).

DESCRIPTION.

The changa (fig. 1) is an insect found throughout the island, living in galleries in the ground. It is about 1¼ inches long in its adult stage; its color is a light brownish fawn more or less mottled with darker areas above and a uniform light brown beneath. Its shape is approximately cylindrical and proportionately longer than that of the true cricket. The head has a pair of moderately long antennæ, of about eighty joints, which are exceedingly sensitive; a pair of well-developed eyes, and between and slightly above these are two comparatively large ocelli, or secondary eyes; and two pairs of jaws, one pair being very strong and possessing six teeth and a blade each.

The expression of the face has a fancied resemblance to that of a monkey, whence the name, "chango," being the popular name in Spanish for a pet monkey.

The top of the prothorax, which is that part of the body immediately behind the head, is somewhat shield-shaped and strongly convex, with no median ridge or groove, and is used in pressing back the loose earth at the top and sides of the burrow. When in the act of burrowing the head and prothorax are slightly rotated, thus bringing the sides of the latter like a smoothing trowel in contact with the earth wall and keeping it "trimmed."

The abdomen is flattened beneath and strongly arched above; it is terminated by a pair of slender, flexible stylets, the office of which is unknown; the so-called genital plates are very similar in both sexes, and there is no ovipositor in the female.

The first pair of legs are good examples of specialized structure; all the parts are greatly modified and peculiarly adapted to the excavation of burrows or tunnels in the earth. The first joint is proportionately short and has a bony process which supports the second and third joints when inflexed. The second joint is large and produced beyond the third joint into a spade-like tooth which braces the teeth of the fourth joint from the inside when the leg is bent at the beginning of a stroke. The third joint is so short and broad as to be almost triangular and is unarmed, but has a strong ridge at its outer and lower side which holds the fourth joint from twisting when doubled back. The tibia, or fourth joint, is extremely irregular in shape, strongly attached to the third joint, and possesses a pair of large bone-like projections which are slightly concave on the outside. The auditory organ is situated on the front of the upper part of the tibia and is protected by a raised fold of the surface; it may be noticed as a white membrane stretched drumhead-like over a cavity near the third joint. Thus it can truly be said that the changa "hears through its elbows," though that does not prevent its hearing well. The tarsus, or foot, is attached not at the end of the fourth joint but about midway on its outer surface; it has three flexible joints and a pair of separately movable sharp claws at the tip of the last one; the first and second joints, or knuckles, are produced at nearly right angles on the lower side into large, black teeth, more pointed than those of the tibia and supported by the latter except when fully extended.

When closely bent the whole leg has a somewhat elliptical outline and is a model of strength, compactness, and adaptability to purpose. Indeed, with the 4 picks and 10 shovels of its first pair of legs, it is no wonder that the changa can burrow its own length in ordinary soil in the space of half a minute.

The second and third pairs of legs are of medium size; they present several short but strong spines, and their feet have three joints each,

with a pair of claws which are independently movable. Although not structurally fitted for jumping, the three pairs of legs acting in unison suffice to enable the changa to make clumsy leaps of several times its own length.

The wings are fairly large and much exceed the wing covers, extending to the tip of the abdomen; they are nearly twice as long as broad and are very delicate and folded into minute plaits.

The tegmina, or wing covers, are short, rounded, thin, and more flexible than is usual among the insects of this order; the tegmina of the males have a fairly well-developed stridulating organ, which can be seen upon close examination to be composed of several strong veins about the center of the wing cover which are provided with tooth-like ridges, and it is by rubbing these veins together that the male produces his short and low, but distinctive, chirrup.

The entire surface of the body is covered with a short, sparse, yellowish down, though in adult specimens the head, legs, and wing covers are nearly naked. These minute hairs serve to prevent the surface of the body from becoming wetted by contact with the very wet soil through which the changa sometimes has to burrow; it also, by holding the air, enables the changa to float readily upon the surface of water, and this fact enables it, when washed out of the surface soil into a stream or pool, to escape drowning. The integument of most parts of the body is soft and so nearly transparent that the tracheæ, or breathing tubes, may be seen ramifying directly beneath it. These tracheæ, or tube-like lungs, radiate from the large abdominal spiracles through which the changa breathes. These breathing pores, 12 in number, are situated in two longitudinal rows—one on either side of the abdomen.

LIFE HISTORY.

The eggs of the changa are deposited in a heap on the floor in the enlarged end of a side gallery, and from a few inches to a foot or more beneath the surface of the ground. They are of a dirty yellowish color, elliptical in outline, smooth, and about 3 mm. in length by 1 mm. in diameter. They are laid in January, February, and March, and hatch in about two weeks. It is possible that the egg-laying season varies much, according to climatic conditions and the individual female, for eggs in some stage of formation are usually to be found in female specimens at whatever time of the year the examination is made. Each female deposits from 50 to 100 eggs, and it is believed she dies soon after ovipositing, but this has not been proved in our breeding-cage experiments, because the adult specimens generally die within two weeks after entering the cages.

The young changa is at first nearly white, but soon changes to a dark-fawn color above and its exterior is everywhere clothed with short hairs of the same color. The larva, as the young is termed,

shows greater activity and saltatory powers; it can readily jump twenty-five times its own length. The growth of the young changa is comparatively slow and maturity is probably never reached within one year, and perhaps a year and a half is not a long life for a changa in this region. The Northern mole cricket (*Gryllotulpa borealis*) is believed to live for three years. It is not known how many times the skin is cast, but probably there are at least three, and perhaps five, moults before reaching maturity.

GENERAL HABITS.

The young changa very seldom leaves the ground unless driven out by water, but the adults are frequently to be seen hurrying over the surface even in the daytime. Their gait is more clumsy and irregular than is the case with most crickets. When greatly excited they supplement their ordinary gait with short jumps.

The adult males frequently fly at night and are attracted to light. Though their flight is laborious, like that of a large beetle, and not long sustained, they sometimes rise to a light 20 feet or more above the ground. They seem to prefer dark, cloudy nights in which to make their aerial excursions. There are doubtless other conditions which are important regarding the flight of the changa, because of two apparently very similar evenings the changa may emerge in great numbers in one, whereas during the other scarcely a single one may be seen. From 7 o'clock until 10 o'clock are the hours preferred for their flights. Thus it does not, as has been stated, fly only at twilight.

The changa is sensitive to humidity. Unless the surface of the soil is moist they remain at a depth of several inches, and if the soil is saturated they come to the surface and escape or remain hidden in grass clumps. Whenever the soil is moist and not too hot, be it night or day, its work of destruction is carried on, though, of course, much the greater amount of damage is done at night. Its habit of burrowing just beneath the surface in a great measure saves it from the attacks of lizards, but not entirely from fowls and blackbirds, that are quick to notice the slightest movement of the earth on top of the burrow and to recognize the cause thereof. These burrows may be traced often for several feet, or even yards, the loosened and raised convex surface plainly indicating the course taken, and at the end of the visible portion of the burrow there may be noted an opening, either the entrance or exit, or else the descent of the burrow. These burrows, ramifying through the soil in the vicinity of food plants, are kept open and utilized for a considerable length of time by all the mole crickets frequenting that soil area. Thus it will be seen a changa can readily pass from the roots of one food plant to those several feet, or perhaps even yards, distant without emerging from the ground or making any new gallery. This fact partially accounts for the great

number of small seedling plants which may be destroyed by one or two crickets in a plat of ground in the space of one night. Keeping the earth pressed firmly about the roots of a plant closes the burrows and greatly hinders the changa's operations.

When removed from the ground, or sometimes when surprised on the surface, the adult changa has the habit of feigning death. This "'possum" act may be prolonged several minutes. After a few minutes of intense activity directly after coming to a light, the changa usually strikes an attitude of meditation, as it were, and remains absolutely motionless for a considerable length of time.

The female of the northern mole cricket (*Gryllotalpa borealis*) is said to care for her young until they reach the second moult; but though we have often found very young changas they were always apparently unattended.

FOOD HABITS.

The changa's food consists almost wholly of living plants; the stomach, however, is always found to contain more or less mud and sand, which is probably unavoidably eaten along with the roots. Portions of decaying plants and the leaves and stems of living plants are sometimes eaten. When food is scarce the leaves and roots of plants, especially those of the "yerba dulce," are drawn into the galleries, sometimes to a distance of a foot or more, there to be consumed at leisure during the daytime. In captivity, even with plenty of its normal food, the changa will eat the dead and dying individuals of its own kind; and we suspect that it varies its normal diet with an occasional earthworm, should their respective galleries happen to cross; indeed, we have kept specimens in cages on an unmixed diet of earthworms for a week and more.

The usual point of attack on a plant is the crown or junction of stem and roots, but the whole root system and a good part of the stem is frequently devoured. In eating the stem the changa often remains just beneath the surface and pulls down the plant as fast as it is consumed; thus a plant 4 inches in height in the evening may appear only 1 or 2 inches high the next morning.

Plants having a poisonous or acrid sap are free from attacks. The economic plants most injured by the changa are cane, tobacco, and rice. Among the small crops the tomato, eggplant, turnip, and cabbage are most affected. Very little is known as to the extent of the damage upon the coffee crop, but a considerable percentage of the young seedlings in the nursery beds belonging to the experiment station have been deprived of their taproots. Young seedlings of citrus fruits are frequently attacked, but much of the loss usually attributed to the changa is due to the grubs of the orange-leaf weevil (*Exophthalmus spengleri*), or to those of the smaller May beetle (*Lachnosterna*

sp.), or to a peculiar bacterial or fungus disease known locally as "sancocho," which causes the bark of the roots and stem near the soil surface to decay.

Of ornamental plants the coleus seems to be a favorite food. The castor-oil plant, watermelon, bean, sweet potato, cassava, and "yautia" are seldom or never attacked.

It seems that in its habit of gnawing away a ring of bark from roots and underground parts of stems of some plants and of eating directly into the heart of others the changa shows a sort of mania for killing quite beyond its hunger-satisfying instinct.

INTRODUCTION INTO PORTO RICO.

It is the current belief among the better-informed agriculturists here that the changa first reached Porto Rico in a shipload of guano brought from South America about the year 1850, but since the same species is found throughout tropical America from Uruguay to Florida it seems more probable that the changa was here before the guano arrived. However, it was not universally considered a serious pest until after the hurricane of '76, which practically destroyed its worst enemy, the blackbird. For the next few years the changa was so abundant in some localities that they often came to the lights in the houses in such numbers as to literally cover the floors with a loathsome wriggling mass of their bodies. Since about 1885 their numbers were slightly diminishing until the hurricane of August 8, 1899. It is said by some that they first appeared in the west end of the island and have gradually migrated eastward.

The vicinity of Mayaguez was the first district of the island to suffer from this plague, and it happens that the estate recently purchased by the insular government for the permanent use of the experiment station at Mayaguez, which was formerly known as "La Carmen," was the first estate to abandon the cultivation of cane on account of the ravages of the changa and the cane disease which was believed to always follow the changa's attacks.

INFLUENCE OF SOIL CONDITIONS.

The mountain districts of the interior are usually more free from the changa than the coast region. This is very largely due to the fact that the mountain soils are clayey, while those of the coast plains and the broad valleys are of an alluvial sandy loam. It is obvious that the changa can not work in clay, on account of its tenacious and noncompressible nature; while in the loose granular structure of a loamy soil the changa readily presses aside the particles of earth and forms a gallery without excavating or bringing to the surface any of the displaced material.

As previously stated, saturation or overdryness of the soil are conditions avoided by the changa. Prolonged rains in lowlands are probably destructive to many of the young, which have to come to the surface to escape drowning; and during a prolonged drought they descend to a considerable depth, and it is possible that in an open field some of the young die from their inability to find food or to migrate, as do the adults, by an overland trip.

We find that the changa evinces an aversion to making a surface burrow up the side of a plant hill or ridge of earth. For this reason single plants should be "hilled up" when practicable.

In sandy cane lands two and sometimes three plantings of the cane are necessary on account of the greater numbers, as well as greater destructiveness, of the insect in these soils; whereas in a cane soil that carries a high percentage of clay, as in those in the vicinity of Rio Piedras, only about 1 per cent of cane cuttings is destroyed by the changa. These rules hold good also for tobacco, rice, and other crops; the more clayey the soil the less damage can be done by the changa to crops grown therein. There is a difference of opinion among cane planters here as to the method of setting the cane cutting in the soil. Some aver that the cutting has a better chance of life when planted horizontally, because of the number of roots produced at all the nodes, while others claim that a changa will remain near a cutting until all the tender roots are devoured anyway, and therefore the upright position is better, which gives the continually forming roots a chance to grow and harden beyond the changa-food stage between the brief visits of the changa. But we believe the best plan to avoid the attacks is to lay the cane cutting, with its leaves still attached, upon the soil in a slight depression. Thus as the young roots start they are toughened by the influence of the air and the light, and when they are covered with the hoe, lightly at first and more deeply later, they are too hard for the changa's jaws.

Though our personal observations have not yet extended over an entire year, there is little doubt that the changa's period of greatest activity, as evinced by their coming to light and by their depredations in fields, is at the end of the rainy season; that is, in October, November, and December.

REMEDIES.

Generally speaking, preventive measures seem more advisable for small crops or limited areas than destructive remedies, with one exception, viz, the use of trap lights.

We may group the prophylactic remedies into two classes—the physical, or those which prevent the attacks of the changa by obstructions, and chemical, or those which prevent the attacks by the use of chemical substances having a repellent odor.

The most common means of preventing the destruction of small plants is by wrapping them in the leaves of the mamey (*Mammea americana*). This method is very common among the tobacco growers of the island. At the time of transplanting, the young plant with a small quantity of earth is wrapped in one or two mamey leaves laid lengthwise around the ball of earth; when placed in the soil the leaf forms an impassable barrier, although there is some danger that the changa may hop over the top ring of leaves or enter at the bottom and thus gain access to the plant itself. We find, however, from our experiments at the station that the wrapping of the young plant in this manner retards the growth of its root system and probably in a measure suffocates the roots by preventing the free circulation of air and water in the soil about them. The thickness and gummy sap of the leaf prevent its decay in the soil for from two to six weeks. If carefully placed, however, the leaf or leaves may be drawn from the soil after the plant has attained sufficient size and vitality to enable it to resist the changa's attacks. Sections of banana leaves are also used like those of the mamey.

An improvement upon the mamey-leaf wrapper is the wire gauze "sleeve." This system has been successfully used by the Porto Rico Fruit Company, at Bayamon, in saving a plat of tomatoes in a badly infested district. Galvanized-iron wire cloth having meshes too small to admit the passage of a half-grown changa is cut into pieces about 6 by 10 inches. These pieces are rolled into cylinders, into which the young plants are set at the time of transplanting. These cylinders have the advantage of lasting for several seasons, of allowing the roots to extend outside the cylinder, and of allowing a thorough ventilation of the soil. These sleeves may be made of various dimensions to suit the kind and size of plant to be protected. It is always necessary to see that the vertical edges overlap a little, so that an entrance can not be forced between them; and it is well to allow the top rim of the cylinder to protrude 1 or 2 inches above the surface of the soil. Their diameter should never be less than 3 inches, except for very small plants; the length may be 6 to 12 or more inches.

Cheese cloth has been tried as a barrier, with not much success, because it rots very quickly, and as soon as it begins to rot the changa readily forces a way through it. Cheese-cloth covers for raised wooden beds and seed boxes have been successfully used by the American Fruit Company, at Rio Piedras. The cheese cloth was stretched on square frames of the same width as the boxes, and these frames were removed during the daytime. They effectually prevented the entrance of the changa during its nocturnal migrations.

A mulch of tobacco stems just below the surface of the soil proves quite ineffectual; the galleries are made even more readily through it.

Tobacco dust separately or mixed with other fertilizers is likewise nonpreventive.

The use of the pomace from the castor-oil presses has also been tried, but with little success. All parts of the castor-oil plant are known to be poisonous when eaten, and it was thought that its presence about seedling plants would keep away the changa; but unless a great quantity of the seed-cake refuse is used, the changa readily passes through it.

Barriers made by pouring coal tar into a depressed narrow ring in the soil about a plant and then lightly covering it with earth have been tried without success. A desperate changa will even tunnel directly through the tar itself, apparently oblivious to its strong odor.

Clean cultivation may be called a physical remedy. The removal of weeds and grass from a cultivated crop necessarily removes a portion of the changa's food plants, and although at first thorough cultivation seems to indirectly incite the changa to even more ferocious depredations, we have found that the adults emigrate from a clean cultivated field; it is obvious, of course, that the wingless specimens must remain, or else make an overland trip, which is strongly contrary to their instinct. Many of our first experimental plats were completely devastated during the first three or four months of our occupation of the grounds at Rio Piedras, but by keeping down the "yerba dulce" and all other native food plants of the changa their numbers have rapidly decreased until at present the only damages are those perpetrated by occasional tramp-like specimens. Moreover, keeping the ground clean around and between the cultivated plants affords a much better opportunity to the insectivorous birds for detecting the changa; so much so that in a clean cultivated open field, which is well policed by birds, it is almost sure death to a changa to appear above ground, or even to disturb the surface soil in its tunneling operations during the daytime.

Whenever practicable a field should be plowed and kept free from weeds for several weeks prior to planting. This plan not only starves out the pests, but gives the birds a chance to destroy them.

Special search with hoe or spade in badly infested grounds just after a heavy rain may sometimes be relied upon to rid a plat of ground of changas. In this way the pests may be kept in control in small areas at a slight expense.

Several years ago the idea was conceived by several native planters to form a society or corporation with a capital of some hundreds of thousands of dollars for the extermination of the terrible pest. Their idea was to establish substations throughout the island, at which a bounty would be paid for every specimen of changa brought in. It was thought that by paying a cent apiece, or perhaps less, the incentive would be so strong that the task of exterminating the plague

would be readily and rapidly accomplished. Although many of the more wealthy agriculturists expressed their willingness to subscribe liberally in this undertaking, the plan was never carriedinto effect. The impracticability of this plan depends largely upon the impossibility of securing all the specimens in a given area; if even 1 per cent were left it would be merely a question of time when the task would need to be done over again.

The subject of trap lights has attracted considerable attention, especially within the last two or three years, but for some reason their use has never become universal. In badly infested districts planters frequently light large fires of grass or brushwood during nights when changas are flying abundantly on their plantations. The effectiveness of these dull smoking fires is probably not so great as might be expected, for our experiments show that the changa is not attracted by a dim light. Two or three forms of cumbersome and complicated lanterns have been devised; and one device especially deserves mention for its ingenuity—a lantern suspended above a cloth funnel leading into a tin receptacle at the bottom. This plan renders practicable the use of the living insects caught in the cloth funnel as food for fowls. The old Spanish agronomic substation at Martin Peña, near Rio Piedras, experimented with a trap light, but we can find no records of these trials.

Our experiments show that the best and cheapest form of trap light is a lantern (the larger the better), suspended above a receptacle partially filled with water, to which a little kerosene has been added. The changa is drawn to the light and striking the chimney of the lantern or lamp falls into the receptacle beneath. The water in this receptacle gives it stability and the layer of kerosene on top quickly kills the changas by stopping their breathing pores. The cost of running a trap like this is from 1 to 5 cents a night, depending, of course, upon the size of the wick used. A coat of tar spread over a level surface of boards or zinc beneath the light holds fast nearly all of the insects which drop into it, but it was found much less satisfactory than kerosene, principally because the surface soon dries or becomes clogged. Probably an electric light or acetylene gas light would be much more advantageous than a lantern, but the cost would perhaps be prohibitive.

Lights placed at the sides of a field should be provided with reflectors to throw all the light into the field. Fortunately there seems to be very few species of beneficial insects caught in the traps here; on the contrary, two species of cutworms, two or three species of the very injurious May beetles (*Lachnosterna* spp.), and the very numerous leaf-hoppers which infest plants of the bean family are caught in considerable numbers in the traps. A chimneyless trap light has proved almost utterly valueless as a changa killer; the flame is smoky

and even a light breeze causes the tin sides to become coated with a deposit of soot, which of course destroys their reflecting power. The cost of a trap light should not be above $2, and by using a common lantern and five-gallon kerosene tin, the cost may be under $1; the cost of oil should not be above 3 cents a night, even if the light be burned during the entire night, which is unnecessary, since the changa does not fly much during the cool hours after midnight.

Among the repellent remedies which have been tried at the station naphthalin has been found the most effective. The flake, or white crystalline form, was the kind considered. Various experiments have been tried with this substance placed in holes in the soil at various distances apart and at various distances from the plants. It was found to have little or no deleterious effect upon the plant itself, even when considerable quantities were placed close to the roots of tender plants; but its volatile nature renders it necessary to repeat the treatment every two to five days, depending upon the nature of the soil and upon the temperature of the atmosphere. We found that a dose of one-half to one drachm of the crystals in holes one to two and a half inches deep and 1 foot apart would prevent the entrance of the changa into the included area; renewing the naphthalin charge every three to four days kept the soil saturated with the vapor. An adult changa placed in a closed liter jar with 1 drachm of naphthalin becomes paralyzed in about three hours, but is not absolutely dead until after twelve hours. The cost of naphthalin is now only 5 or 6 cents per pound, but even at this low price its use is advisable only for valuable plants in clean cultivated areas.

Many experiments have been tried with carbon bisulphid, or "fuma." These show that although a moderate quantity of the substance suffices to repel the changa, its extremely volatile character and its somewhat high price (12 to 20 cents per pound) practically prohibits its use as an economic reagent. The vapor of "fuma" seems to be less obnoxious to the changa than that of naphthalin, although it is of course a much more powerful insecticide. An adult changa placed in a closed liter jar becomes paralyzed within one minute after the addition of two or three drops of the liquid; and death soon follows unless the specimen be removed from the vapor. However, an adult specimen placed in an air-tight wooden box containing 150 cubic inches with 5 drops of "fuma" dies in from three to ten hours—that is, by a physiological effect of the poison rather than by asphyxiation. Two drachms of the liquid in a 2-drachm vial with a loose stopper of cotton or tin foil was found to last from two to five days when sunk in ordinary soil to a depth of 3 inches below the surface.

Similar experiments have been tried with creosote and creolin; but without stating the uninteresting details of these tests, suffice it to say that even by using a comparatively large quantity of these substances

placed in different manners beneath the surface of the soil, little or no repellent action was observed; even young changas will make new burrows directly over a partially closed vial of creolin, although its poisonous effect in a closed receptacle is as great, perhaps, as that of carbon bisulphid. An adult specimen in a box containing 150 cubic inches does not become paralyzed so quickly, but is killed in a shorter time than is the case with the use of "fuma" and with no reviving period between paralyzation and death from the poisoning action. A solution of creolin, containing one-half drachm of the pure liquid in 1 quart of water, poured into the soil around plants serves to repel the changa from a very small area for a comparatively short time.

Pure kerosene poured into the soil about young plants also repels the changa so long as the soil retains strong traces of it; but its harmful action upon plant tissues precludes its use except in extreme cases. A strong kerosene emulsion when poured liberally over a badly infested area will drive out the majority of the changas beneath the surface.

Lime liberally spread over plats has little or no effect in expelling or repelling the changa.

Arsenic in its various compounds is found to be the best substance for combating the changa plague; but its use is attended with some difficulties. The best method of applying it seems to be the following: A quantity of "yerba dulce" plants are gathered and shaken free of dirt and cut into pieces of an inch or less in length; then white arsenic or Paris green is sprinkled over the chopped pieces of grass and the whole thoroughly mixed together so that each piece of the grass will contain more or less of the arsenic. This poisoned bait is then put upon, or just beneath, the surface of the soil in badly infested areas. The changa will come to this bait even when wilted. It is well to lightly cover this poisoned bait, so that fowls will not eat it. A good proportion is one-half ounce of Paris green (or white arsenic) to every quart (liter) of the chopped grass, though of course this formula may be varied considerably. It is well to moisten the grass before sprinkling on the poison, and we believe there is a slight advantage in adding sugar to the water used in wetting the grass. Instead of putting a large quantity of the bait in one place, it is more economical to strew it in lines or narrow rows among the plants near areas where surface burrows are numerous. Death ensues within a very few hours after eating the bait. Since most of the poisoned insects retire to their deepest retreats when suffering from the effects of the poison and die there, the bodies are not readily found by the ants; but if a specimen chances to die near the surface a procession of ants will mark the spot within a few hours. Thus the result of this remedy is not readily seen and its efficiency may therefore be doubted by the hasty observer. But the continued use of the remedy can not fail to keep in

check, if not fully exterminate, the enemy in the treated area. Pure Paris green is better for the above treatment than the white arsenic, but at present it is not readily procurable in the island. It can usually be purchased from dealers in agricultural implements for about 20 or 25 cents per pound. The common arsenic, the powdered form of arsenious trioxid, can be purchased at any local drug store, although a physician's permit may be required. Even allowing for a very liberal waste, 5 ounces of arsenic, when used with "yerba dulce," or a similar bait, properly applied and distributed, should be sufficient to kill practically all the changas in 1 acre of ground within one week.

We find that cuttings of coleus stems 3 or 4 inches in length, dipped in white arsenic powder and laid upon the surface of the soil, is another remedy for the same trouble.

NATURAL ENEMIES.

Unfortunately the changa has few natural enemies in Porto Rico. Its habits of emerging only at night, of spending nearly all its time well hidden beneath the surface of the ground, its comparatively large size, and its great strength, activity, and fecundity, combine to render it peculiarly exempt from the dangers which beset the lives of most insects. There is a singular lack of ground beetles of the family Carabidæ here. With a greater abundance of these predaceous enemies of plant-eating insects, the early stages of the changa would be passed in less security. The parasitic flies (Tachinidæ), which trouble the lives of many species of insects, can obviously never affect the changa. The hair snake (*Gordius aquaticus*) in its third (?) larval stage lives in the abdominal cavity of various species of grasshoppers in the United States, devouring the fatty tissues and finally the viscera. A very large percentage of the black mole crickets (*Stenopelmatus talpa*) of Mexico are similarly eaten piecemeal. But although we have examined hundreds of specimens of both sexes of the changa, we have never found the slightest trace of any internal or external parasites. Moreover, no trace of any fungus disease has been detected on the changa. In the near future we hope to experiment with the fungus which attacks grasshoppers in the Central States. This fungus (*Empusa grylli*) has been successfully used to inoculate individuals, which are then turned loose in the fields, where they carry contagion and death to the noninfected individuals. It is extremely doubtful, however, if this fungus can be inoculated into the changa, on account of the widely different habits of the grasshopper and the mole cricket, as well as the different climatic conditions here.

The red mite (*Trombidium locustarum*), which is so common a parasite on grasshoppers in the United States, does not attack our changa.

Probably the most important natural enemy of the changa is a species of blackbird called here the "judia" (the jewess) on account

of its enlarged upper mandible. These birds hover about cultivated fields and pastures, and one may often be seen darting down from a tree or fence post on to the surface of the ground and hopping back to its perch with a changa in its beak. Of course they can accomplish this kind act to the farmers and themselves only when the changa, on account of the condition of the soil and of the weather, is working at or just beneath the surface. Several other species of birds, the "mazambique," the "mirlo," one which happens to have the name of "chango," and others are also enemies of the changa. These birds frequently take up their residence near cultivated fields, and should of course be encouraged in this by the farmers who should see that the law protecting the birds is vigorously enforced.

The common lizard also consumes considerable numbers of the changa, but, of course, it can work only in the daytime; besides, a lizard under 6 inches in length can only with great difficulty manage to swallow an adult changa. They may be noticed frequently running about in cultivated fields and gardens carrying in their mouths changas which they are unable to swallow, but which they are determined to hold on to as long as possible. Many changas would probably escape from the small-sized lizards were it not for the fact that a large lizard follows the nonethical custom of dispossessing a weaker brother of his prey whenever an occasion offers.

Domestic fowls often learn to follow a plow and pick up the changas and grubs which are turned up with the earth.

It has been suggested that the horned toad of Mexico and Southern United States might become an important enemy of the pest, but it is extremely doubtful if that desert animal could withstand our humid climate; moreover its habits are strictly diurnal.

The common toad of the United States, being nocturnal in habit, may prove of some use in intercepting occasional marauding changas, and arrangements have already been made to introduce it into this island.

Combined and intelligent effort toward judicious and persistent application of the remedies as advised in this bulletin will keep the changa under control in Porto Rico.

The changa is justly considered one of the greatest difficulties the Porto Rican agriculturist has to deal with at present, but it is not sufficiently important to prevent the successful cultivation of any tropical product in the island. Indeed, its injuriousness has been frequently overestimated by discouraged planters; it has been blamed for the unprofitablensss of various crops in many localities when poverty of the soil, fungus and bacterial diseases, poor agricultural methods, or unfavorable ecological conditions have been the true causes.

SUMMARY.

The changa is a comparatively large insect of the order Orthoptera; its habits are subterranean and nocturnal; its food consists largely of roots of plants. The female lays her eggs in the galleries under ground. The life of an individual is about one year. Its enemies are lizards and birds, but since these are strictly diurnal in habit, the changa suffers comparatively little from them.

The damage to crops in this island by the changa amounts to probably more than $100,000 annually. The crops injured most are cane, tobacco, and rice; a few crops are exempt from attack. The depredations extend over the entire year.

Comparatively little damage is done in clayey soils; moist, sandy loam is preferred. Saturation and extreme dryness of the soil are conditions which prevent the changa's operations.

The old method of protecting the roots of seedling plants with mamey leaves is more or less deleterious to the plants; but the great cheapness of this method commends it to the tobacco grower. The coarse wire gauze cylinder is recommended for tomatoes and valuable plants.

Clean cultivation, both before and after planting crops, is recommended, because a large portion of the changa's ordinary food supply is thus cut off. Hilling up is also recommended where practicable. Special search with hoe or spade soon after a rain may be relied upon to some extent in small plats.

Plowing during the winter and spring months will bring to the surface numbers of the eggs and young larvæ, and this exposure to their enemies will result in the death of a large percentage of their numbers.

Trap lights are recommended for use on nights when the changa is flying in numbers. A dim light is nearly useless. A large lantern having a reflector and set at the edge of a field or a lantern with no reflector set in the middle of a field, will give best results.

Arsenic or Paris green sprinkled on chopped grass is the best bait; this poison should be distributed in small patches or narrow rows just beneath the surface of the soil.

Naphthalin placed in the ground about plants serves to repel the changa, but its use is warranted only in small and badly infested areas.

AGRICULTURAL PUBLICATIONS REGARDING PORTO RICO.

The following publications relating to Porto Rico have been issued by the United States Department of Agriculture, and may be had by addressing the honorable Secretary of Agriculture:

Porto Rico. Agricultural. 151, Yearbook, 1898.

Porto Rico Agricultural Experiment Station. Reprint from the Office of Experiment Stations Report, 1901.

Puerto Rico Trade. Foreign Markets Bulletin No. 13.

Porto Rico. Dairy Industry and Dairy Markets. Reprint from Eighteenth Annual Report, Bureau of Animal Industry.

Porto Rico. Notes on the Animal Industry. Reprint from the Sixteenth Annual Report, Bureau of Animal Industry.

Porto Rico. Hurricanes. Weather Bureau Bulletin No. 32.

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